(4121-104)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re United States Patent Application of:	)	
Applicants: **PASTYR, Otto et al.**	)	
Serial No.: **09/043,951**	)	**Group Art Unit:** **5611**
Date Filed: **March 27, 1998**	)	
Title: **CONTOUR COLLIMATOR FOR RADIOTHERAPY**	)	

FIRST CLASS MAIL CERTIFICATE

I hereby certify that this paper is being deposited this date with the U.S. Postal Service as First Class Mail in an envelope addressed to the Assistant Commissioner for Patents, Box Missing Parts, Washington, DC 20231, under the provisions of 37 CFR 1.8.

Candi L. Riggs

Candi L. Riggs

May 26, 1998

Date

SUBMISSION OF DECLARATION AND POWER OF ATTORNEY, SMALL BUSINESS ENTITY STATEMENT, AND ASSIGNMENT IN RESPONSE TO NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE IN U.S. APPLICATION NO. 09/043,951

Assistant Commissioner for Patents
Box PCT
Washington, D.C. 20231

06/01/1998 [illegible]
01 FC:254

Sir:

In response to the April 11, 1998 Notification of Missing Requirements, enclosed and submitted herewith are the following executed documents:

- Declaration and Power of Attorney;
- Small Business Entity Statement; and
- Assignment.

A check in the amount of $105.00 is enclosed, including the surcharge for delayed filing submission of the oath or declaration and appertaining documents relating to small business entity status, of $65.00 (37 CFR § 1.16(e)) and $40.00 as the assignment recordation fee for the enclosed Assignment document in favor of Deutsches Krebsforschungszentrum Stiftung Des Offentlichen Rechts. Please charge any deficiency in payment and credit any excess payment to Deposit Account No. 08-3284 of Intellectual Property/Technology Law.

Respectfully submitted,

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FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		4121-104 U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/043951
INTERNATIONAL APPLICATION NO. PCT/DE96/01892	INTERNATIONAL FILING DATE 1 OCTOBER 1996	PRIORITY DATE CLAIMED 2 OCTOBER 1995

TITLE OF INVENTION

CONTOUR COLLIMATOR FOR RADIOTHERAPY

APPLICANT(S) FOR DO/EO/US

Otto Pastyr, Wolfgang Schlegel, Karl-Heinz Hover, Wolfgang Maier-Borst

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).*
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A small entity statement.
16. ☐ Other items or information:

NOTE: This application is being filed without an Oath or Declaration under the provisions of 37 CFR § 1.53 in order that applicants may secure a filing date of March 27, 1998. Upon receipt of a "Notice to File Missing Parts - Filing Date Granted," a Declaration and Power of Attorney, and an Assignment in favor of applicants' assignees, Deutsches Krebsforschungszentgrum Stiftung Des Offentlichen Rechts, will be filed in the Patent and Trademark Office. The undersigned agent affirmatively states that he has been duly authorized and appointed to file this application on behalf of the applicants and applicants' assignees, and that the Declaration and Power of Attorney to be filed hereafter will confirm the undersigned agent's authorization and appointment. Deutsches Krebsforschungszentgrum Stiftung Des Offentlichen Rechts is a small business entity within the meaning of 37 CFR § 1.9, and an appertaining small entity statement will also be submitted for such assignee in response to a Notice to File Missing Parts.

17. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Search Report has been prepared by the EPO or JPO $910.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $0.00		
No International preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $0.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,010.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $0.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 910.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	20 -20 =	0	X **$22.00**	$	
Independent Claims	1 - 3 =	0	X **$74.00**	$	
Multiple dependent claim(s) (if applicable)			+ **$230.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 910.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ 455.00	
SUBTOTAL =				$ 455.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 455.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEE ENCLOSED =				$ 455.00	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of $455.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 08-3284. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not yet been met, a petition to revive (37 CFR 1.127(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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STEVEN J. HULTQUIST
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Assistant Commissioner for Patents
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Washington, D.C. 20231

Sir:

Prior to examination of the above-identified new national phase patent application, please amend the application, as follows:

In the Claims

Amend claims 1-19 as follows:

1. (amended) A contour collimator [(1)] for radiotherapy, comprising a plurality of plate-shaped diaphragm elements [(101,102, 103, . . .)] provided in a guiding block [(10)] and movably arranged with respect to one another to form a contour diaphragm for a radiation beam [(13)] emitted by a radiation source [(12)] towards the collimator, and comprising at least one drive for moving the diaphragm elements, [characterized in that] wherein a drive [(111, 112, 113, . . .)] of its own is associated with each diaphragm element [(101, 102, 103, . . .)], [that] the drives [(111, 112, 113, . . .)] of a group of diaphragm elements [(101, 102, 103, . . .)] are arranged substantially adjacent to one another, and [that] a driving transmission [(121, 122, 123, . . .)] of its own is provided between each drive [(111, 112, 113, . . .)] and the associated diaphragm element [(101, 102, 103, . . .)].

2. (amended) The contour collimator according to claim 1, [characterized in that] wherein the drives [(111, 112, 113, . . .)] are arranged substantially as a semi-circle.

3. (amended) The contour collimator according to claim 1 [or 2], [characterized in that] wherein each driving transmission [(121, 122, 123, . . .)] has a flexible but tension-resistant and pressure-resistant power-transmitting element [(131, 132, 133, . . .)] one end of which is connected with the associated diaphragm element [(101, 102, 103, . . .)] and the other end of which is connected with the associated drive [(111, 112, 113, . . .)] and which is supported in a moving guide [(141, 142, 143, . . .)] in translatorily movable fashion.

4. (amended) The contour collimator according to claim 3, [characterized in that] wherein each power-transmitting element [(131, 132, 133, . . .)] is detachably coupled to the associated diaphragm element [(101, 102, 103, . . .)] via a coupling linkage [(151, 152, 153, . . .)].

5. (amended) The contour collimator according to claim 3 [or 4], [characterized in that] wherein each power-transmitting element [(131, 132, 133, . . .)] is detachably coupled to the associated drive [(111, 112, 113, . . .)] via a further coupling linkage.

6. (amended) The contour collimator according to [any one of claims] claim 3 [to 5], [characterized in that] wherein each power-transmitting element [(131, 132, 133,. . .)] has a spring band.

7. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein each drive [(111, 112, 113, . . .) is formed by] comprises a linearly acting motor.

8. (amended) The contour collimator according to claim 7, [characterized in that] wherein the motor [(111, 112, 113, . . .)] is an electric linear motor.

9. (amended) The contour collimator according to claim 7, [characterized in that] wherein the motor [(111, 112, 113, . . .)] is an electric motor having a linearly acting gearing [, preferably] selected from the group consisting of a rack-and-pinion gear [or] and a spindle gearing.

10. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein the guiding block [(10)] has upper [(16)] and lower guide plates [(17)] which are each provided with a plurality of upper guide grooves [(161, 162, 163, . . .)] and lower guide grooves [(171, 172, 173, . . .)], respectively, for the diaphragm elements [(101, 102, 103, . . .)].

11. (amended) The contour collimator according to claim 10, [characterized in that] wherein the upper [(16)] and lower guide plates [(17)] are each provided with a [preferably] rectangular opening [(18, 19)] which determine the maximum diaphragm opening and have a common middle plane [(20)] extending substantially rectangularly

with respect to the longitudinal direction of the guide grooves [(161, 162, 163, . . . ; 171, 172, 173, . . .)].

12. (amended) The contour collimator according to [any one of claims] claim 3 [to 11], [characterized in that] wherein the moving guides [(141, 142, 143, . . .)] are arranged substantially side by side in a moving guide block [(14)] and have moving guide gaps diverging in fan-shaped and bent fashion, in which one power-transmitting element [(131, 132, 133, . . .)] each is accommodated in translatorily movable fashion.

13. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein two superposed planes of drive arrangements are associated with each moving guide block [(14)], one power-transmitting element [(131, 132, 133, . . .)], accommodated in adjacent moving guides [(141, 142, 143, . . .)], being applied by two superposed drives [(111, 112,1 13, . . .)] each.

14. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein two opposite groups of tanslatorily drivable diaphragm elements [(101, 102, 103, . . . ; 101', 102', 103', . . .)] are provided in the guiding block [(10)], two opposite diaphragm elements [(101, 101'; 102, 102'; 103, 103'; . . .)] each being guided in lower [(161, 161'; 162, 162'; 163, 163'; . . .)] and upper [(171, 171'; 172, 172'; 173, 173'; . . .)] common guide grooves.

15. (amended) The contour collimator according to [any one of the preceding claims} claim 1, [characterized in that] wherein each diaphragm element [(101, 101', 102, 102', 103, 103', . . .)] of a pair of opposite diaphragm elements is movable with its free edge facing away from the respective drive [(111, 111", 112, 112', 113, 113', . . .)] beyond the common middle plane [(20)] of the openings [(18, 19)] in the upper [(16)] and lower [(17)] guide plates.

16. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein at least one displacement pickup [(181, 182, 183, . . .)] preferably a potentiometer,] for detecting the position of the corresponding diaphragm element [(101, 102, 103, . . .)] is associated with each drive [(111, 112, 113, . . .)].

17. (amended) The contour collimator according to claim 16, [characterized in that] wherein displacement pickup [(181, 182, 183, . . .)] has a moving potentiometer which can be actuated translatorily.

18. (amended) The contour collimator according to [any one of the preceding claims] claim 1, [characterized in that] wherein at least one of the diaphragm elements [(106, 107, 108)] located in the region of the central middle ray of the radiation beam [(13)] is provided with at least one thickening rib [(23, 23', 24, 24')] extending in the translational direction.

19. (amended) The contour collimator according to claim 18, [characterized in that] wherein each thickening rib [(23, 23'; 24, 24')] engages a corresponding groove in the adjacent diaphragm element [(107, 108)].

Add new claim 20, as follows:

20. (new) The contour collimator according to claim 16, wherein the displacement pickup comprises a potentiometer.

In the Abstract

Replace the Abstract of the international application with the new Abstract attached in Appendix A hereof.

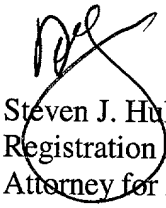
REMARKS

Claims 1-19 have been amended herein for clarity and specificity, and new claim 20 has been added to claim the preferred potentiometer feature formerly recited in claim 16.

A new Abstract has been introduced

It is requested that the examination of this application proceed with respect to claims 1-20 as amended and now pending in the application.

Respectfully submitted,



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APPENDIX A

Abstract of the Disclosure

A contour collimator has a plurality of plate-shaped diaphragm elements movably arranged with respect to each other in a guiding block to form a contour diaphragm for a radiation beam emitted by a radiation source towards the collimator, and at least one drive for moving the diaphragm elements. A drive is associated with each diaphragm element with the drives of a group of diaphragm elements being substantially adjacent, and a driving transmission arranged between each drive and the associated diaphragm element.

Contour collimator for radiotherapy

This invention relates to a contour collimator for radiotherapy, comprising a plurality of plate-shaped diaphragm elements movably arranged with respect to each other in a guiding block to form a contour diaphragm for a radiation beam emitted by a radiation source towards the collimator, and at least one drive for moving the diaphragm elements.

Such a contour collimator is known from EP 0 387 921 B1. In radiotherapy, such contour collimators serve for forming a diaphragm whose opening corresponds to the contour of the area of the human body to be irradiated, so that the high-energy rays emanating from the radiation source only impinge on this area and the surroundings of this area are shielded from the radiation.

The known contour collimator provides for each group of a given number of plate-shaped diaphragm elements a common adjusting part which serves for serially moving one select diaphragm element each relative to the remaining diaphragm elements. For this purpose, a gear of the adjusting part meshes with a rack provided at the diaphragm element and a non-rotary, toothed area of the adjusting part meshes with the rest of the diaphragm elements to fix them. In order to accelerate the adjusting step, the prior art proposes to provide two such adjusting parts on either side of the contour collimator.

For moving the individual diaphragm elements, the prior art makes necessary that the respective adjusting part is initially moved translatorily and transversely to the diaphragm elements, so that the adjusting gear comes into engagement with the rack of a select diaphragm element. Then, a rotation is applied to the gear to move the associated diaphragm element. This process has to be repeated for each diaphragm element of a group.

It is the object of the present invention to create a contour collimator of the generic kind, which can be adjusted more rapidly and altogether has a simpler and thus operationally more reliable design requiring less maintenance.

According to the characterizing part of claim 1 this object is achieved in that a drive is associated with each diaphragm element, that the drives of one group of diaphragm elements are substantially adjacent to one another and that a driving transmission is provided between each drive and the associated diaphragm element.

In spite of the distance which is laterally very narrow between the individual diaphragm elements and corresponds approximately to the thickness of a diaphragm, e.g. 1 mm, it is possible with this design to equip each diaphragm element with a drive of its own thus actuating it separately. This serves for considerably accelerating the adjusting time for a contour collimator, so that the irradiation time for each patient is reduced in one respect, which is a relief for the patient and is also simultaneously accompanied by an increase in economic efficiency.

In an advantageous embodiment, the drives are arranged substantially as a semicircle. This serves for obtaining an especially simple and clearly arranged design in which the driving transmissions have substantially equal length, so that equal components can be used for the design.

In a further advantageous embodiment, each driving transmission has a flexible towards tension-resistant and pressure-resistant power-transmitting element, one end of which is connected with the associated diaphragm element and the other end of which is connected with the associated drive and which is movably supported in translatory fashion in a moving guide. Such a power-transmitting element permits an especially flexible arrangement of the drives.

When each power-transmitting element is detachably coupled to its associated diaphragm element via a coupling linkage, this creates a simple design of the contour collimator, which also permits the rapid exchange of individual elements without any difficulties.

The same advantage occurs when each power-transmitting element is detachably coupled to its associated drive via a coupling linkage.

Each power-transmitting element advantageously comprises a spring band.

Each drive is preferably formed by a linearly acting motor. This renders possible an especially slim or narrow design of the arrangement of drives, so that the arrangement of drives can be very compact.

In this connection, the motor is preferably an electric linear motor.

As an alternative, the motor is an electric motor having a linearly acting gearing, preferably a rack-and-pinion gear or a spindle gearing.

When the guiding block has upper and lower guide plates each of which is provided with a plurality of upper guide grooves and lower guide grooves, respectively, for the diaphragm elements, an especially reliable and fail-safe adjustability of the diaphragm elements is guaranteed.

In a preferred embodiment, the upper and lower guide plates are each provided with a preferably rectangular opening, which determine the maximum diaphragm opening and have a common middle plane extending substantially rectangularly with respect to the longitudinal direction of the guide grooves.

When the moving guides are arranged substantially side by side in a moving guide block and have moving guide gaps which diverge in bent and fan-shaped fashion and each of which accommodates a power-transmitting element in translatorily movable fashion, safe guidance of the power-transmitting elements is achieved, so that an accurate translatory adjustment of the diaphragm elements is possible, since undesired bulging of the power-transmitting elements is prevented by the gap walls tightly abutting against the respective power-transmitting element.

An especially compact arrangement will be formed when two superposed planes of drive arrangements are associated with each moving guide block, two superposed drives each being applied to one power-transmitting element accommodated in contiguous moving guides. By this, the overall width of the contour collimator can be limited effectively in spite of a plurality of movable diaphragm elements.

When two opposite groups of translatorily drivable diaphragm elements are provided in the guiding block, two opposite diaphragm elements each being guided in upper and lower common guide grooves, on the one hand, the provision of the opposite groups of diaphragm elements creates the possibility of adjusting contours rotating about an angle of 360° and, on the other hand, it is made possible to achieve complete screening in the area of said guide groove by contact of two opposite diaphragm elements.

When each diaphragm element of a pair of opposite diaphragm elements is movable with its free edge facing away from the respective drive beyond the common middle plane of the openings in the lower and upper guide plates, contours can be produced which have strong constrictions on one side as is the case e.g. with kidney-shaped contours.

It is preferred to associate with each drive a displacement pickup, preferably a potentiometer, for detecting the current position of the corresponding diaphragm element.

This serves for enabling an accurate control of the diaphragm element positions, so that e.g. the contour can automatically be adjusted by a computer program.

This embodiment is especially reliable and inexpensive when the displacement pickup has a moving potentiometer which can be actuated translatorily.

If at least one of the diaphragm elements disposed within the region of the central middle ray of the radiation beam is provided with at least one thickening rib extending in the translational direction, reliable shading of the central middle ray will be achieved, since the thickening rib shades the middle ray extending parallel to the diaphragm element. As an alternative, the diaphragm elements can be inclined towards the ray. Moreover, the top of a middle diaphragm element can alternatively be thicker than its bottom.

This shading effect is even intensified when each thickening rib meshes with a corresponding groove in the adjacent diaphragm element.

The invention is explained in more detail below with reference to the drawing by means of an example; wherein

fig. 1 is a perspective top view onto a contour collimator according to the invention;
fig. 2 A is a partial view of a guiding block, which is broken away, with some diaphragm elements being inserted;
fig. 2 B is a side view of a guiding block in the translational direction of the diaphragm elements;
fig. 2 C is a section of fig. 2 B, which shows the diaphragm elements inserted in the guide rails in the region of the lower guide plate;
fig. 3 is a perspective top view onto a second embodiment of a contour collimator which is provided with displacement pickups;

fig. 4 is a sectional view through a contour collimator corresponding to the longitudinal middle plane IV-IV in fig. 3, indicated in dash-and-dot lines, in a first position of the diaphragm elements;
fig. 5 is a sectional view corresponding to the section in fig. 4 in a calibration position of the diaphragm elements;
fig. 6 is a view in which a power-transmitting element is mounted on a diaphragm element;
fig. 7 shows different diaphragm elements with and without thickening ribs; and
fig. 8 is a diagram of the ray shading of a contour collimator according to the invention.

Fig. 1 is a perspective view of a contour collimator according to the invention whose core is formed by a guiding block 10 which is illustrated in detail in figs. 2 A to 2 C.

The guiding block 10 has a lower guide plate 17, an upper guide plate 16 as well as two side walls 21 and 22. A substantially rectangular opening 18 is provided centrally in the upper guide plate 16. A lower opening 19 which is in substantially vertical alignment with the upper opening 18 is provided centrally in the lower guide plate 17. The top side of the lower guide plate 17 is provided with a plurality of lower guide grooves 171, 172, 173, ... extending in the longitudinal direction of the lower guide plate 17 and formed parallel to one another at equal lateral distance and on one side of the lower opening 19. The upper and lower guide plates 16, 17 are made preferably of brass, bronze or ceramics or a radiation-resistant material having good sliding properties.

Further lower guide grooves 171', 172', 173', ... are developed on the other side of the lower opening 19 in alignment with the lower guide grooves 171, 172, 173, ... In the same way, upper guide grooves 161, 162, 163, ... and further upper guide grooves (not shown) which are in

alignment with the guide grooves 161, 162, 163, ... and are formed on the other side of the upper opening 18 are provided on the bottom side of the upper guide plate 16.

Since the guiding block 10 is made symmetrically with respect to the middle plane 20 extending rectangularly relative to the guide grooves 161, 162, 163, ...; 171, 172, 173, ...; 171', 172', 173', ... and through the center of openings 18 and 19, only the design of the guiding block on one side with respect to the middle plane 20 is described below for the purpose of simplification. The design on the other side is formed analogously thereto.

A plate-shaped diaphragm element 101; 102; 103; ... is inserted in movably translatory fashion in each pairing of the vertically superposed guide grooves 161, 171; 162, 172; 163, 173; ...

As is evident from fig. 2 C, the width of the individual guide grooves 161, 171, ... corresponds to about half the thickness of a diaphragm element 101, ..., the thickness of a plate-shaped diaphragm element being about 1 mm. A ridge 171" is formed between two adjacent guide grooves 171, 172. Its width is somewhat greater than the width of the adjacent guide grooves 171, 172 and thus also somewhat greater than half the width of a diaphragm element. Each diaphragm element has a section 101" of reduced thickness at its lower edge, which section is inserted in its associated guide groove 171 and is translatorily movable therein. Although an analogously developed upper section of reduced thickness which engages the guide groove 161 is not shown in the drawing, the upper edges of the diaphragm elements 101, 102, 103, ...as well as the upper guide plate in the region of the upper guide grooves 161, 162, 163, ... are developed analogously to the lower edges of the diaphragm elements 101, 102, 103, ... and the lower guide plate 17 in the region of its guide groove 171, 172, 173, ..., as illustrated in fig. 2 C.

Because of the differing widths of the guide grooves 171, 172, 173 and the ridges 171", 172" disposed therebetween, the diaphragm elements 101, 102 inserted in the guide grooves 171, 172 are slightly spaced laterally, so that they do not come into contact.

The diaphragm elements are provided with coupling linkages 154, 155 at their vertical edge facing away from the middle plane 20, as evident from fig. 2 A by means of plates 174 and 175. The coupling linkages 154, 155 are alternately developed in the vicinity of the lower guide plate 17 and the upper guide plate 16, so that they are displaced upwardly or downwardly in each case when the diaphragm elements are disposed side by side.

Such a coupling linkage is shown in more detail in fig. 6 for the diaphragm element 105. The coupling linkage 155 comprises a stepped recess 155' located in one side of the diaphragm element 105. A pivot 155" is provided in the more recessed portion of the stepped recess 155', which is left untouched during the manufacture of the recess and which corresponds to the full thickness of the diaphragm element 105. This recess 155' is produced by milling out the surface of the metallic diaphragm element which is preferably made of tungsten.

The more recessed region of the stepped recess has such a dimension that a hook-like recess 135' of a power-transmitting element 135 can be inserted in this more recessed region and grips behind the pivot 155". In this case, the thickness of the power-transmitting element corresponds approximately to the height of the step within the stepped recess 155' and is preferably 0.30 mm, while the height of the power-transmitting element is about 13 mm. The power-transmitting element 135 consists preferably of spring steel.

After inserting a cover plate 155"' in the less recessed region of the stepped recess 155' and anchoring it, the

power-transmitting element 135 with its hook-like recess 135' is suspended in the more recessed portion of the stepped recess 155', the pivot 155" being thus gripped behind. This prevents the power-transmitting element 135 from laterally falling out. In this way, a particulated coupling linkage 155 is formed between the diaphragm element 105 and the power-transmitting element 135.

Each of the flexible but tension-resistant and pressure-resistant power-transmitting elements 131, 132, 133, ..., 135, ..., made of spring steel, is accommodated in an upper moving guide and lower moving guide, respectively. Fig. 1 only shows the upper moving guides 141, 143, 145. The moving guides for the power-transmitting elements which are associated with the diaphragm elements 102, 104, ... whose lower regions are provided with the coupling linkage, are arranged underneath the moving guides shown in fig. 1 in a plane which is disposed underneath.

Like those of the plane disposed underneath - the moving guides 141, 143, 145, ... are arranged in outwardly bent and fan-shaped fashion, the radius of curvature of the moving guides decreasing outwardly, which means that the radius of curvature of the moving guides 141 is less for the power-transmitting element 133 of the diaphragm element 101 placed closer to the side wall 21, i.e. the curvature is greater than the radius of curvature for a power-transmitting element of a diaphragm element located more closely towards the middle. On the other side, i.e. towards the other side wall 22, the radius of curvature of the moving guides decreases again, so that there the curvature increases again. In this way, the power-transmitting elements are fanned at an angle of about 180° as shown in fig. 1.

At their fanned, free ends, the power-transmitting elements 131, 132, 133, ..., 135, ... are each coupled to a drive 111, 112, 113, ..., 115, ... developed as a linear drive. Thus, driving transmissions 121, 122, ..., 125, ... for

transmitting the linear motion produced by the respective drive to the associated diaphragm element are created by this coupling between the respective drive 111, 112, 113, ..., 115, ... with the power-transmitting element 131, 132, 133, ..., 135, ..., the coupling linkage 151, 152, ..., 155, ... with the respective diaphragm element 101, 102, ..., 105, ...

The fanning, shown in fig. 1, of the individual driving transmissions 121, 122, ... permits in an especially advantageous manner the arrangement of a plurality of drives 111, 113, 115, ... side by side on the most confined space, the arrangement shown in fig. 1, of the drives in two superposed planes, increasing the compactnessas again as illustrated by means of drives 111 and 112.

Correspondingly, in the example shown in fig. 1 the odd diaphragm elements - when the diaphragm elements located side by side are numbered - are provided in their upper region with the coupling linkage to which the respective power-transmitting element is coupled which extends to an upper row of drives via an upper fan-shaped arrangement of moving guides, while the lower region of the even diaphragm elements include the coupling linkage which pivots them to the power-transmitting elements, which extends through a lower fan-shaped arrangement of moving guides to a lower row of drives. This arrangement makes possible to attach a very large number of extremely narrow diaphragm elements closely side by side and apply a drive of its own to each of them.

An alternative embodiment of the arrangement shown in fig. 1 is illustrated in fig. 3, only few reference numerals being entered for the purpose clarity. A displacement pickup 181, 183 is associated with each driving transmission 121, 123 in the region of the associated drive 111, 113, which measures the degree of translatory movement and passes it on to a control circuit. The position of each individual diaphragm element 101, 103, ... can be

determined by these displacement pickups 181, 183, ... which are preferably formed by sliding potentiometers, so that a computer-controlled precise contour can be adjusted in the collimator.

Fig. 4 shows a contour collimator according to the invention in a longitudinal section, a front diaphragm element 107 of a first group of diaphragm elements, driven by a drive 117 via the driving transmission 127 including the power-transmitting element 137, being moved to a position in which the free edge of the diaphragm element 107, located in the region of the openings 18 and 19 in the upper guide plate and the lower guide plate 17, respectively, projects from the middle plane 20, so that the diaphragm element 107 shades over 50 % of the longitudinal extension of the opening 18 and 19, respectively. The opposite diaphragm element 107' of a second group has been retracted from its drive 117' via its power-transmitting element 137' to such an extent that its free edge facing the openings 18, 19 has come out of the cross-section of the openings 18 and 19, respectively.

Thus, as shown in the case of the associated displacement pickup 187 the possible travel s of the driving transmission 127 is greater than the longitudinal extension l of the opening 18 and 19, respectively, by the amount of x. This renders possible to produce contours with the contour collimator according to the invention, which have strong constrictions on one side, as is the case e.g. with kidney-shaped contours.

A position of the diaphragm elements 107, 107' is shown in fig. 5, in which the respective free edge of the diaphragm elements 107, 107', disposed in the region of the openings 18, 19, abut against a calibration plate 15 extending vertically through the openings 18, 19 and fixed centrally in the middle plane 20. In this position, both diaphragm elements 107, 107' are located symmetrically with respect to the middle plane 20, so that either the associated

displacement pickups 187, 187' can be positioned symmetrically in the setting shown in fig. 5 or the signals applied by these displacement pickups 187, 187' can be stored in a control unit as symmetry reference signals.

Differing kinds of diaphragm elements are shown in fig. 7, the diaphragm elements referred to as a corresponding to those (101, 102, ..., 105) which are dealt with and described above already. The diaphragm elements 106, 107, 108 referred to as b are made for use in the region of the longitudinal middle plane of the contour collimator, which is referred to as IV-IV in fig. 3. As illustrated in fig. 8, the center of the radiation source 12 is usually also located in this longitudinal middle plane, from which source the radiation beam 13 is directed conically downwardly towards the collimator 1.

If type a diaphragm elements were arranged in the region of the longitudinal middle plane IV-IV, the middle ray emitted from the radiation source 12 and the rays directly adjacent thereto would pass through the intermediate spaces of the diaphragm elements in almost unimpeded and non-shaded fashion, so that the collimator would be ineffective in the vicinity of the longitudinal middle plane IV-IV. As shown in fig. 7, the type b diaphragm elements arranged in the region of the longitudinal middle plane IV-IV are provided for this reason with thickening ribs 23, 23' and 24, 24', respectively. In this connection, the thickening ribs extend in the direction of the translational motion of the respective diaphragm elements and over the entire length or at least over more than 50 % of the length of the respective diaphragm element in the translational direction.

The respective thickening ribs 23, 23'; 24, 24' mesh with correspondingly shaped grooves (not shown) on the opposite side of the adjacent diaphragm element, so that the gap between two adjacent diaphragm elements is interrupted by the respective thickening elements in radiation-shielded

fashion. In this way, the passage of the middle ray and the rays adjacent thereto, respectively, is effectively prevented by the gap formed between the type b diaphragm elements as illustrated in fig. 8.

In order to prevent an attenuation of the material of the adjacent type b diaphragm elements in the region of the grooves and the thickenings, the thickenings 23 ,23' and 24, 24', respectively, of two adjacent type b diaphragm elements as well as the associated grooves provided therein are displaced over the height of the respective diaphragm element, as illustrated in fig. 7.

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Claims

1. A contour collimator (1) for radiotherapy, comprising a plurality of plate-shaped diaphragm elements (101, 102, 103, ...) provided in a guiding block (10) and movably arranged with respect to one another to form a contour diaphragm for a radiation beam (13) emitted by a radiation source (12) towards the collimator, and comprising at least one drive for moving the diaphragm elements,
characterized in
that a drive (111, 112, 113, ...) of its own is associated with each diaphragm element (101, 102, 103, ...),
that the drives (111, 112, 113, ...) of a group of diaphragm elements (101, 102, 103, ...) are arranged substantially adjacent to one another, and
that a driving transmission (121, 122, 123, ...) of its own is provided between each drive (111, 112, 113, ...) and the associated diaphragm element (101, 102, 103, ...).

2. The contour collimator according to claim 1,
characterized in
that the drives (111, 112, 113, ...) are arranged substantially as a semi-circle.

3. The contour collimator according to claim 1 or 2,
characterized in
that each driving transmission (121, 122, 123, ...) has a flexible but tension-resistant and pressure-resistant power-transmitting element (131, 132, 133, ...) one end of which is connected with the associated diaphragm element (101, 102, 103, ...) and the other end of which is connected with the associated drive (111, 112, 113, ...) and which is supported in a moving guide (141, 142, 143, ...) in translatorily movable fashion.

4. The contour collimator according to claim 3,

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characterized in
that each power-transmitting element (131, 132, 133, ...) is detachably coupled to the associated diaphragm element (101, 102, 103, ...) via a coupling linkage (151, 152, 153, ...).

5. The contour collimator according to claim 3 or 4, characterized in
that each power-transmitting element (131, 132, 133, ...) is detachably coupled to the associated drive (111, 112, 113, ...) via a further coupling linkage.

6. The contour collimator according to any one of claims 3 to 5,
characterized in
that each power-transmitting element (131, 132, 133, ...) has a spring band.

7. The contour collimator according to any one of the preceding claims,
characterized in
that each drive (111, 112, 113, ...) is formed by a linearly acting motor.

8. The contour collimator according to claim 7, characterized in
that the motor (111, 112, 113, ...) is an electric linear motor.

9. The contour collimator according to claim 7, characterized in
that the motor (111, 112, 113, ...) is an electric motor having a linearly acting gearing, preferably a rack-and-pinion gear or a spindle gearing.

10. The contour collimator according to any one of the preceding claims,
characterized in

that the guiding block (10) has upper (16) and lower guide plates (17) which are each provided with a plurality of upper guide grooves (161, 162, 163, ...) and lower guide grooves (171, 172, 173, ...), respectively, for the diaphragm elements (101, 102, 103, ...).

11. The contour collimator according to claim 10, characterized in that the upper (16) and lower guide plates (17) are each provided with a preferably rectangular opening (18, 19) which determine the maximum diaphragm opening and have a common middle plane (20) extending substantially rectangularly with respect to the longitudinal direction of the guide grooves (161, 162, 163, ...; 171, 172, 173, ...).

12. The contour collimator according to any one of claims 3 to 11, characterized in that the moving guides (141, 142, 143, ...) are arranged substantially side by side in a moving guide block (14) and have moving guide gaps diverging in fan-shaped and bent fashion, in which one power-transmitting element (131, 132, 133, ...) each is accommodated in translatorily movable fashion.

13. The contour collimator according to any one of the preceding claims, characterized in that two superposed planes of drive arrangements are associated with each moving guide block (14), one power-transmitting element (131, 132, 133, ...), accommodated in adjacent moving guides (141, 142, 143, ...), being applied by two superposed drives (111, 112, 113, ...) each.

14. The contour collimator according to any one of the preceding claims,

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characterized in
that two opposite groups of translatorily drivable diaphragm elements (101, 102, 103, ...; 101', 102', 103', ...) are provided in the guiding block (10), two opposite diaphragm elements (101, 101'; 102, 102'; 103, 103'; ...) each being guided in lower (161, 161'; 162, 162'; 163, 163'; ...) and upper (171, 171'; 172, 172'; 173, 173'; ...) common guide grooves.

15. The contour collimator according to any one of the preceding claims,
characterized in
that each diaphragm element (101, 101', 102, 102', 103, 103', ...) of a pair of opposite diaphragm elements is movable with its free edge facing away from the respective drive (111, 111', 112, 112', 113, 113', ...) beyond the common middle plane (20) of the openings (18, 19) in the upper (16) and lower (17) guide plates.

16. The contour collimator according to any one of the preceding claims,
characterized in
that at least one displacement pickup (181, 182, 183, ...), preferably a potentiometer, for detecting the position of the corresponding diaphragm element (101, 102, 103, ...) is associated with each drive (111, 112, 113, ...).

17. The contour collimator according to claim 16,
characterized in
that the displacement pickup (181, 182, 183, ...) has a moving potentiometer which can be actuated translatorily.

18. The contour collimator according to any one of the preceding claims,
characterized in

that at least one of the diaphragm elements (106, 107, 108) located in the region of the central middle ray of the radiation beam (13) is provided with at least one thickening rib (23, 23', 24, 24') extending in the translational direction.

19. The contour collimator according to claim 18, characterized in
that each thickening rib (23, 23'; 24, 24') engages a corresponding groove in the adjacent diaphragm element (107, 108).

Abstract of the Disclosure

A contour collimator (1) has a plurality of plate-shaped diaphragm elements (101, 102, 103, ...) movably arranged with respect to each other in a guiding block (10) to form a contour diaphragm for a radiation beam (13) emitted by a radiation source (12) towards the collimator, and at least one drive for moving the diaphragm elements. A drive (111, 112, 113, ...) is associated with each diaphragm element (101, 102, 103, ...). The drives of a group of diaphragm elements are substantially adjacent. A driving transmission is arranged between each drive (111, 112, 113, ...) and the associated diaphragm element (101, 102, 103, ...).

(Fig. 1 in addition to this)

List of reference numerals

1	contour collimator
10	guiding block
12	radiation source
13	radiation beam
14	moving guide block
15	calibration plate
16	upper guide plate
17	lower guide plate
18	upper opening
19	lower opening
20	middle plane
21	side wall
22	side wall
23	thickening rib
23'	thickening rib
24	thickening rib
24'	thickening rib
101	diaphragm element
101"	section of reduced thickness
102	diaphragm element
103	diaphragm element
104	diaphragm element
105	diaphragm element
106	diaphragm element
107	diaphragm element
107'	diaphragm element
108	diaphragm element
111	drive
112	drive
113	drive
115	drive
117	drive
117'	drive
121	driving transmission
123	driving transmission
127	driving transmission
131	power-transmitting element
132	power-transmitting element

133	power-transmitting element
135	power-transmitting element
135'	hook-like recess
137	power-transmitting element
137'	power-transmitting element
141	moving guide
143	moving guide
145	moving guide
151	coupling
152	coupling
155	coupling
155'	stepped recess
155"	pivot
155"'	cover plate
161	upper guide groove
162	upper guide groove
163	upper guide groove
171	lower guide groove
171'	lower guide groove
171"	ridge
172	lower guide groove
172'	lower guide groove
172"	ridge
173	lower guide groove
173'	lower guide groove
181	displacement pickup
183	displacement pickup
187	displacement pickup

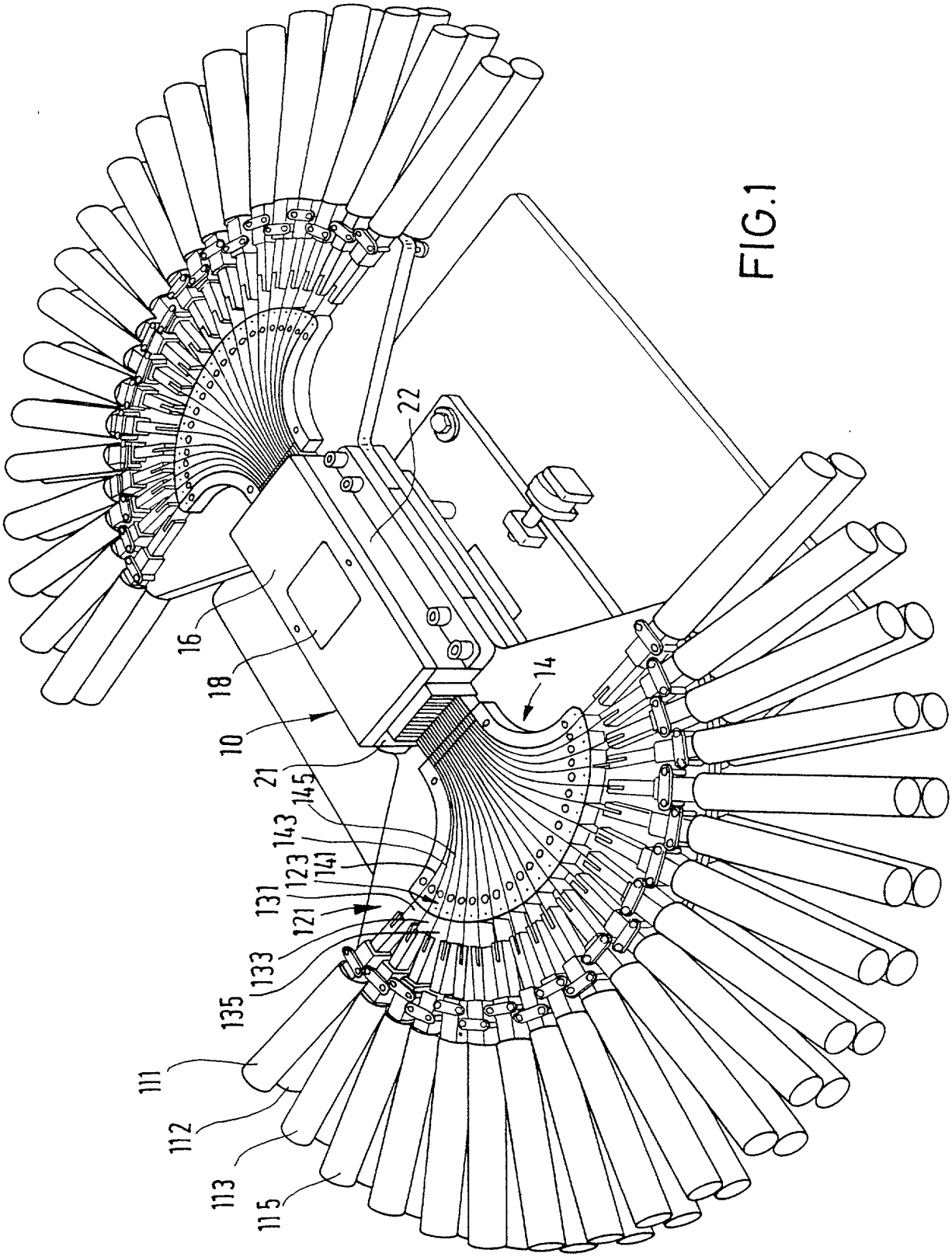
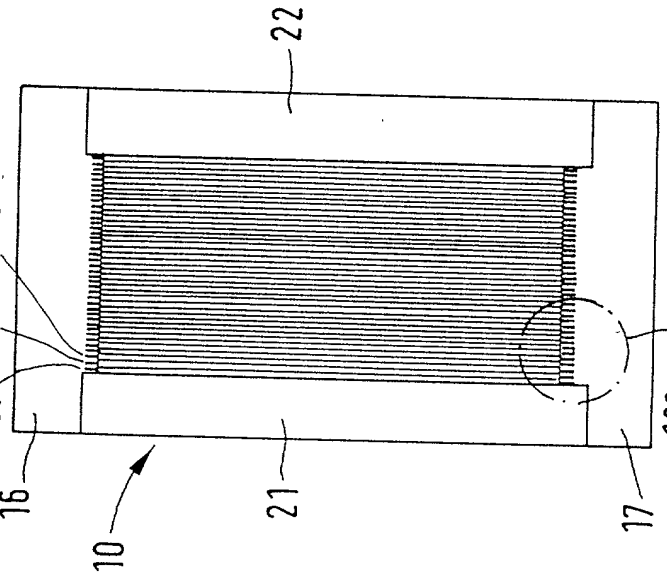


FIG.1

FIG.2B



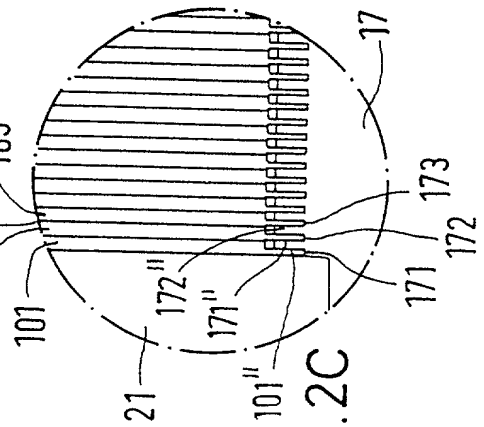
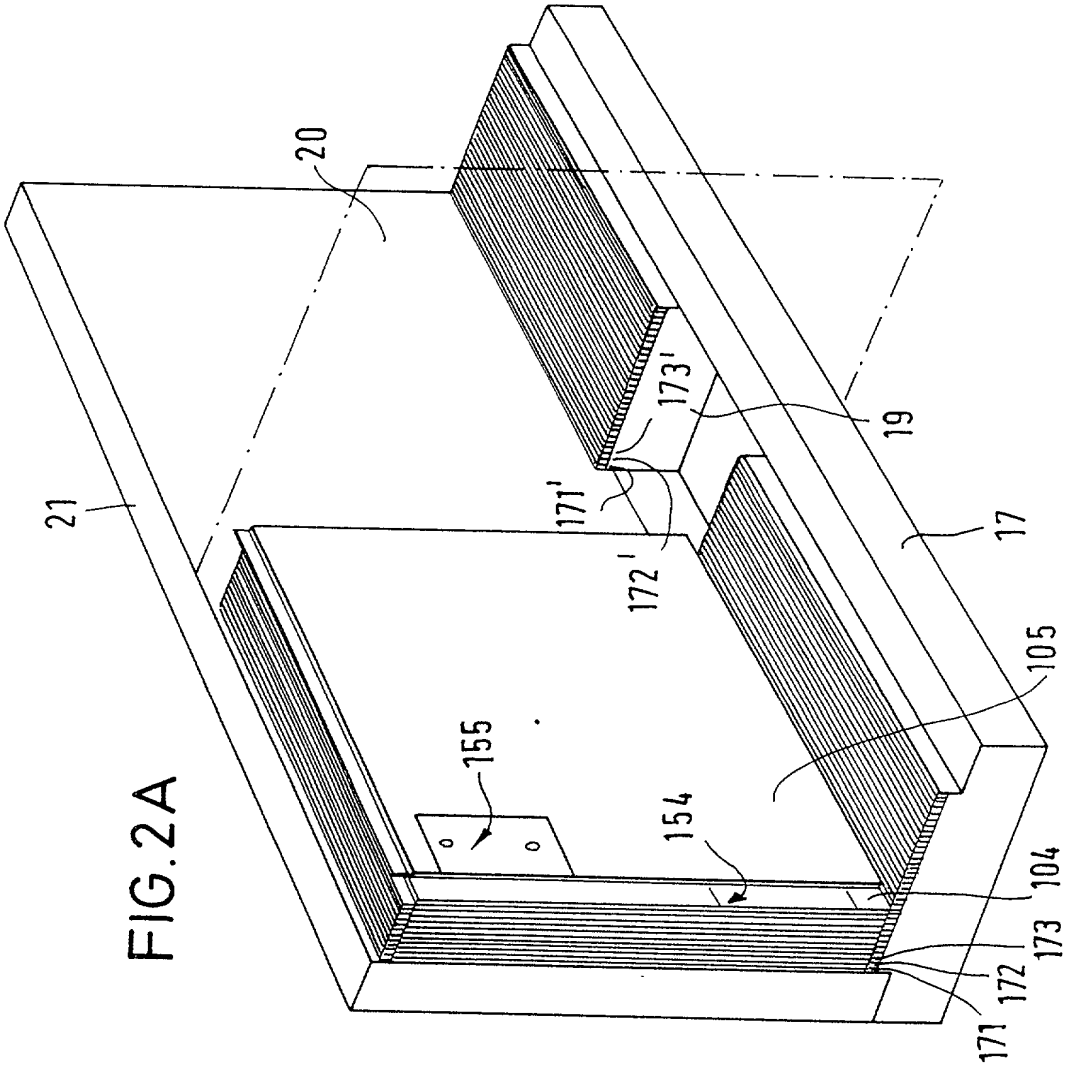


FIG.2C

FIG.2A



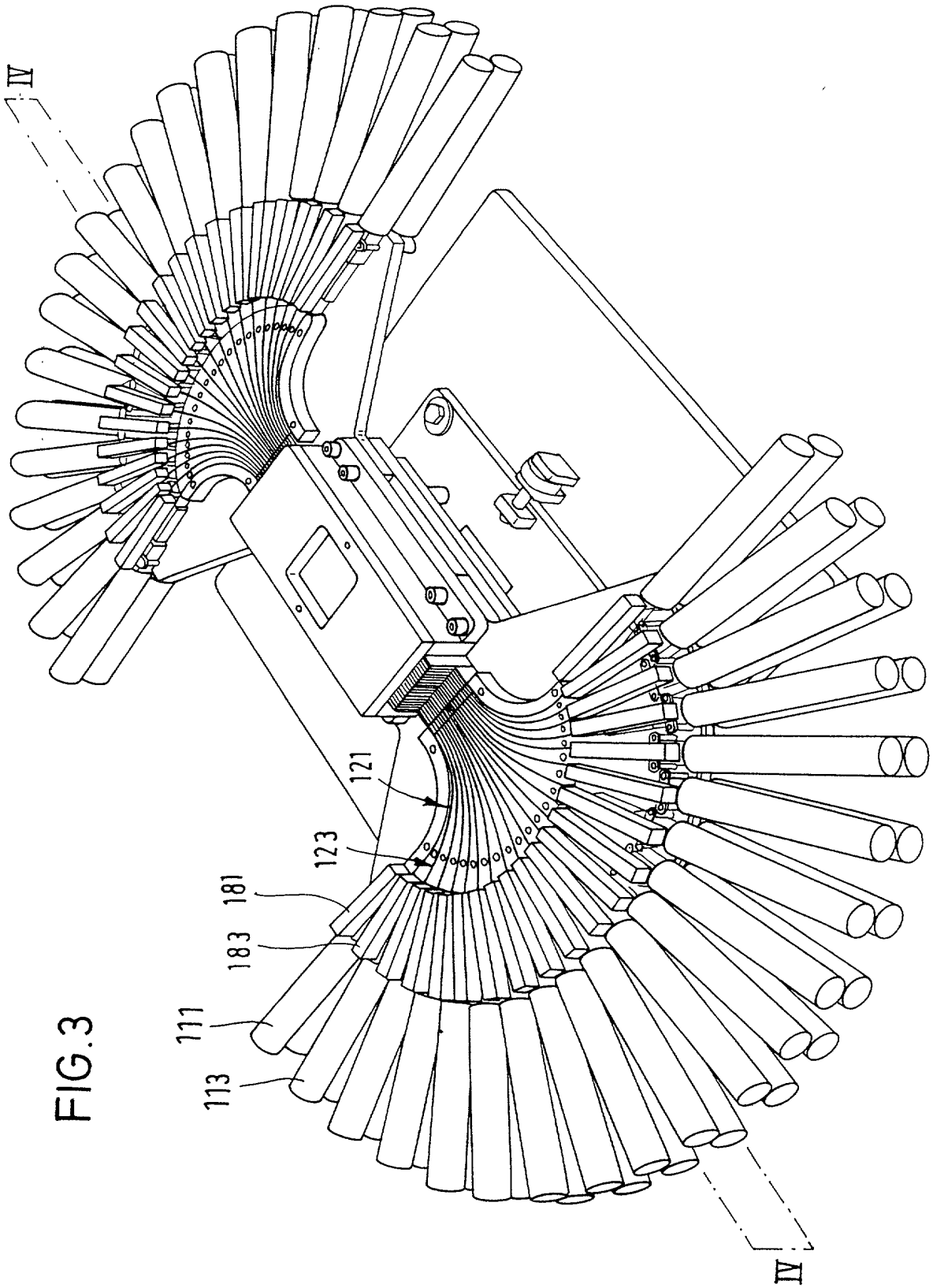


FIG.3

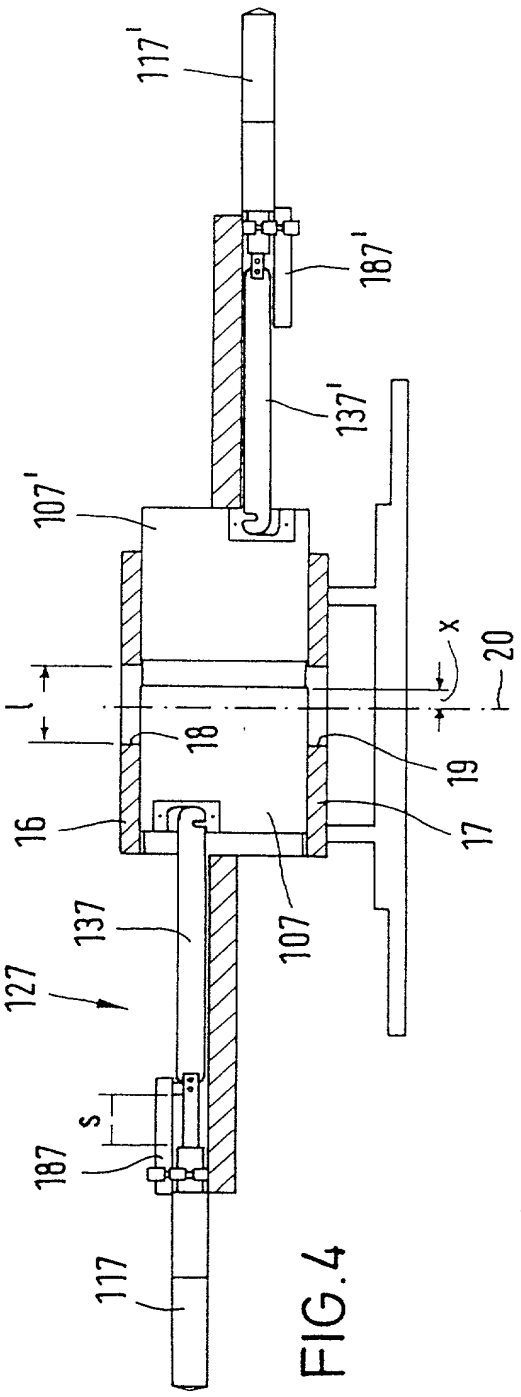


FIG.4

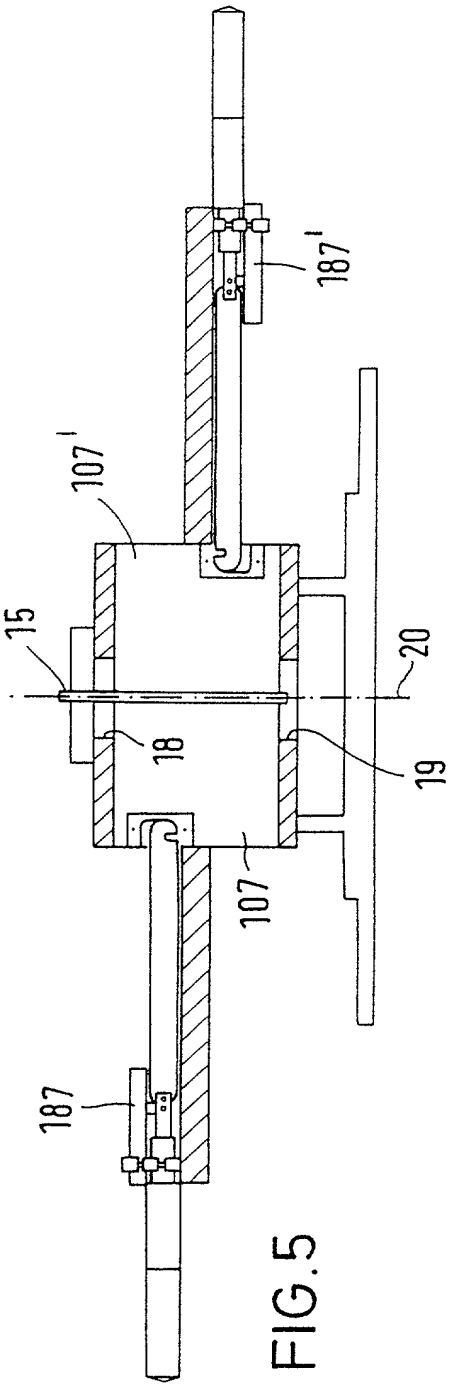
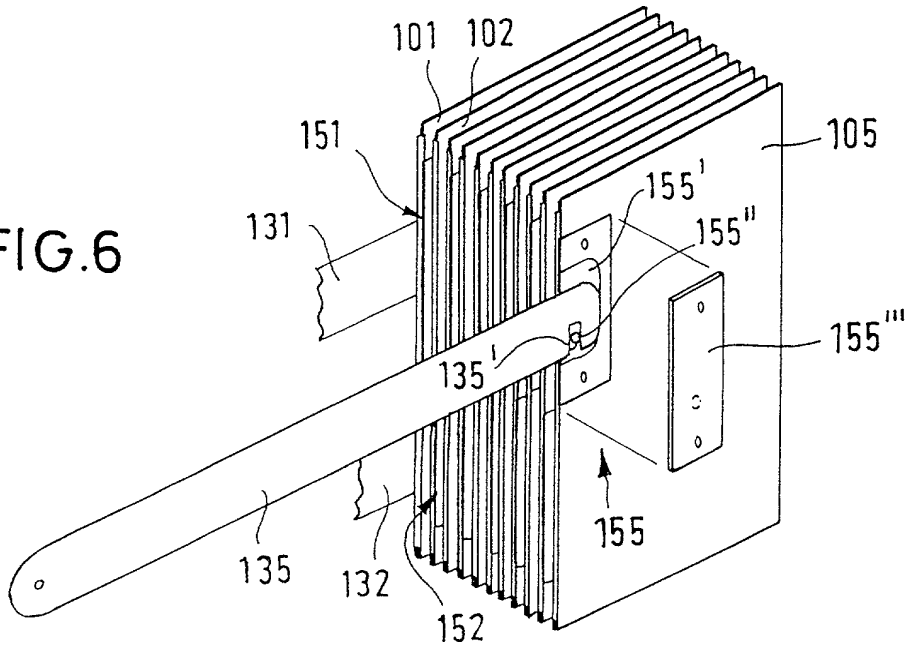


FIG.5

FIG.6



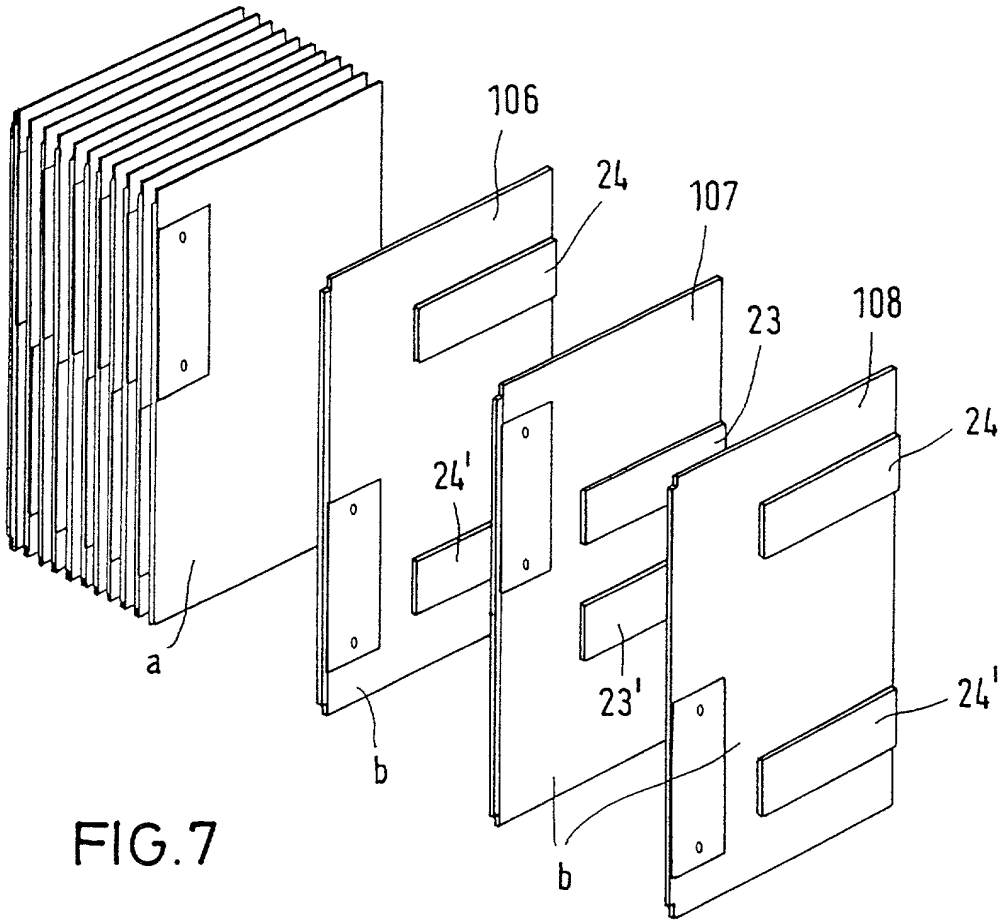
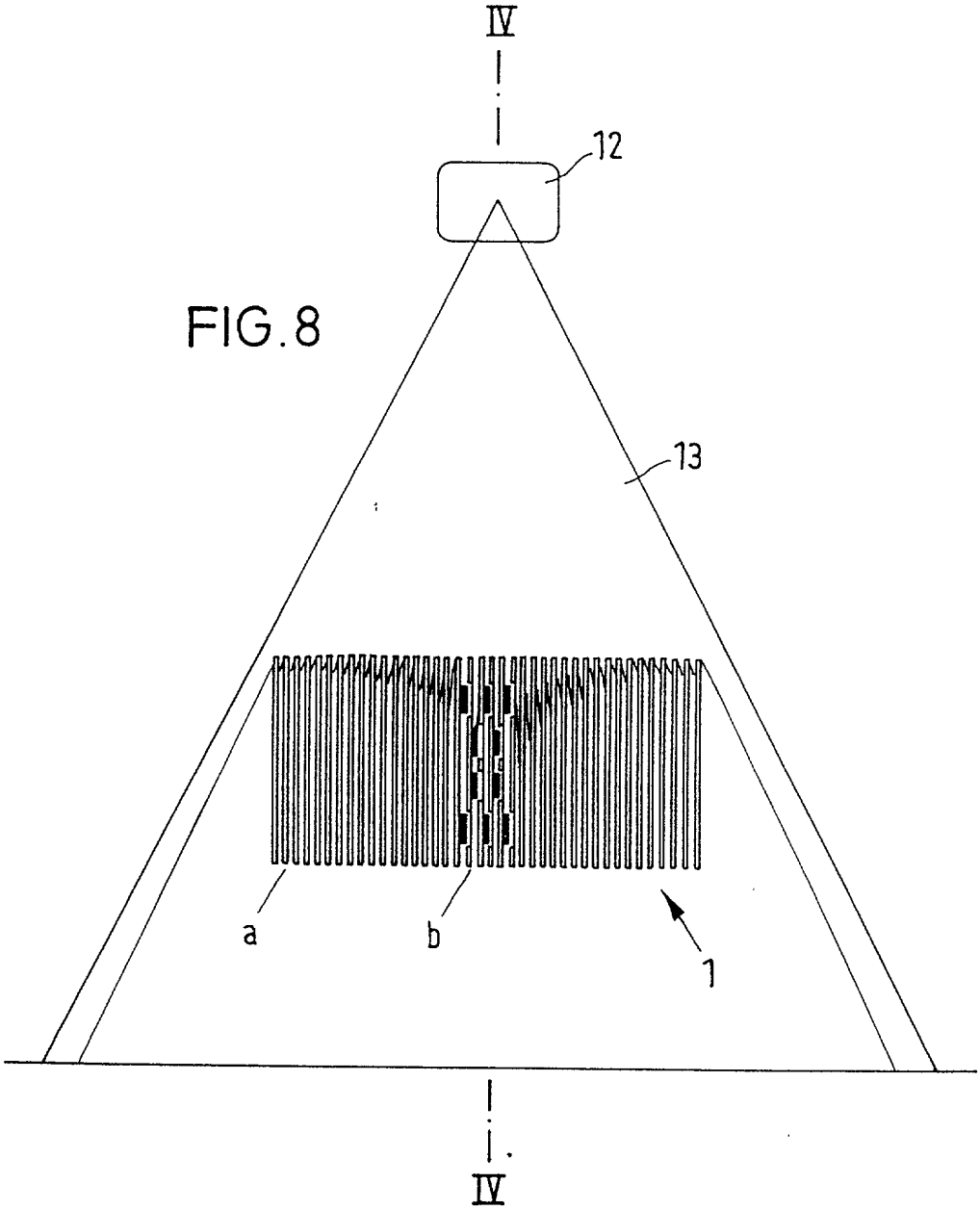


FIG.7

FIG.8



DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Application: **United States Patent Application No. 09/043,951 filed March 27, 1998 in the United States Patent and Trademark Office as a Designated/Elected Office (DO/EO/US) under the provisions of 35 USC §371, based on PCT international application no. PCT/DE96/01892 filed on October 1, 1996, and claiming priority of German patent application no. 195 36 804.5 filed October 2,1995.**

As the below-named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled "CONTOUR COLLIMATOR FOR RADIOTHERAPY," described and claimed in the above-identified United States Patent Application filed in the United States Patent and Trademark Office under the provisions of 35 USC §371.

I hereby state that I have reviewed and understand the contents of the above-identified international application and United States patent application based thereon, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office information which is material to the examination of this United States patent application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate on the invention listed below which were filed within one year prior to the above-identified international patent application:
Prior Foreign Application(s)

195 36 804.5	Germany	2 October 1995	Yes
(Number)	(Country)	(Day/Month/Year Filed)	(Priority Claimed?)

I have also identified below any foreign application(s) for patent or inventor's certificate on the invention having a filing date more than one year before the filing date of the above-identified international patent application, or before the filing date of the above-identified foreign patent application from which priority is claimed:

none

(Number)	(Country)	(Day/Month/Year Filed)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this specification is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code

of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

none

(Application Number)	(Filing Date)	(Status-Patented, Pending, abandoned)

I hereby declare that all rights in the subject matter and invention of the above-identified United States Patent Application fully reside in Deutsches Krebsforschungszentrum Stiftung Des Offentlichen Rechts, Im Neuenheimer Feld 280, D-69120 Heidelberg, Germany and that a confirmatory Assignment executed by all below-named inventors is being concurrently submitted for recordation in the United States Patent and Trademark Office.

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

STEVEN J. HULTQUIST, REG. NO. 28,021
WILLIAM A. BARRETT, REG. NO. 42,296

All correspondence in connection with this application should be sent to:

Steven J. Hultquist
Intellectual Property/Technology Law
P. O. Box 14329
Research Triangle Park, NC 27709
Telephone: (919) 419-9350

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Wolfgang Schlegel Date _____

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3rd

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Inventor's Signature Dr. Wolfgang Maier-Borst Date 08.05.1998

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Citizenship: German

Post Office Address: ____________

09043051.051598

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(e)4 & 1.27(d)) - - FOREIGN NON PROFIT ORGANIZATION

Docket No. 4121-104

Applicants: **Otto Pastyr, Wolfgang Schlegel, Karl-Heinz Hover and Wolfgang Maier-Borst**

Title: **"CONTOUR COLLIMATOR FOR RADIOTHERAPY"**

Filing Date: March 27, 1998 **(EXPRESS MAIL FILING UNDER 37 CFR 1.10)**

I hereby declare that I am:

☐ the owner of the foreign non-profit organization identified below:

☒ an official of the foreign non-profit organization empowered to act on behalf of the concern identified below:

NAME OF NON-PROFIT ORGANIZATION: **Deutsches Krebsforschungszentrum Stiftung Des Offentlichen Rechts**

ADDRESS OF NON-PROFIT ORGANIZATION: **Im Neuenheimer Feld 280, D-69120 Heidelberg**

I hereby declare that the above identified foreign non-profit organization qualifies as a non-profit organization as defined in 37 CFR 1.9(e), for purposes of paying reduced fees to the United States Patent and Trademark Office.

I hereby aver that exclusive rights under contract or law have been conveyed to and remain with the foreign non-profit organization identified above with regard to the invention described in:

☒ The United States patent application filed with the title as listed above, based on international patent application number PCT/DE96/01892 filed October 1, 1996 (35 U.S.C. §371).

☐ Application Serial No. _____ filed _____.

☐ U.S. Patent No. _____ Issued _____.

If the rights held by the above-identified non-profit organization are not exclusive, each individual, concern, or organization having rights in the invention must file separate verified statements averring to their status as small entities, and that no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a non-profit organization under 37 CFR 1.9(e).

Each person, concern or organization having any rights in the invention is listed below:

☒ No such person, concern, or organization exists.

☐ Each such person, concern or organization is listed below:

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27).

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at any time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Prof.Dr. med.Dr.h.c.mult.H.zur Hausen Dr.rer.pol. J. Puchta

TITLE OF PERSON IF OTHER THAN OWNER Chairman a. Scient. Member of the Board Adm.Member of the Board

ADDRESS OF PERSON SIGNING Eichenstr. 69483 Waldmichelbach Eichenweg 1 69198 Schriesheim

SIGNATURE _____ DATE April 22, 1998